SECTION 5: LAND RESOURCES

Introduction to Land Resources and Problems

The TVA region encompasses some 58 million acres. Of this area, non-federal rural land occupies about 50 million acres. Some of the most diverse and beautiful natural resources in the United States are in this seven-state region.

With few exceptions, virtually the entire Tennessee Valley and its adjacent region have been affected by human influences through agriculture, timber harvesting, or other land uses. Over half the Tennessee Valley region is forest lands and about 35 percent is in agricultural land uses. The remaining area is composed of open water, urban areas, and other miscellaneous land uses.

This section contains information about geology and groundwater, agricultural land, forest resources, biological resources, Class I areas, cultural resources, recreational resources, and other land uses.

Geology and Groundwater

The potential of power plants to affect the quality of groundwater is discussed in Section 3 of this document (Volume 2, Technical Document 1, Comprehensive Affected Environment). Groundwater occurs in aquifers of porous soils, sediments, and in fractures and openings of rock formations. Groundwater movement in the region ranges from very slow to very rapid and is completely dependent on site-specific hydrogeology. The distribution of groundwater in the TVA region is influenced by variability in geology, hydrology, and topography among six different physiographic regions.

PROVINCES OF PHYSICAL GEOGRAPHY

The map in *Figure T1-67* shows the TVA region's areas of physical geography. Physical geography determines the location and types of aquifers containing groundwater and the susceptibility of groundwater to various forms of pollutants. Erosion and pollutant runoff into streams are related to physical geography and soil type when power plants or other facilities are built. These aspects will be considered in environmental reviews when a site is chosen for a power plant.

The easternmost part of the region is in the Blue Ridge physiographic province, an area composed of the remnants of an ancient mountain chain. This region has a greater variation in terrain than any other region in the Tennessee Valley. Terrain ranges from nearly level along floodplains to rugged mountains that reach elevations of more than 6,000 feet. The rocks of the Blue Ridge have been subjected to much folding and faulting and are mostly shales, sandstones, conglomerates, and slate (sedimentary and metamorphic rocks of Precambrian age). A few areas, such as Cades Cove, in the Great Smoky Mountains National Park, are underlaid by carbonate rocks that contain large amounts of groundwater in solution openings. In most places, the dense, massive bedrocks contain little groundwater except where they have faulted and fractured.

Located east of the Cumberland Plateau and west of the Blue Ridge province, the Valley and Ridge province has complex folds and faults with alternating valleys and ridges trending northeast to southwest. Ridges have elevations of up to 3,000 feet and are generally capped by dolomites and resistant sandstones on the west sides, while valleys have developed in more soluble limestones and dolomites. The dominant soils in this province are residual clays and silts derived from in-situ weathering. Groundwater occurs mostly in the solution-widened fractures, joints, and bedding planes. Karst features such as sinkholes and springs are numerous in the Valley and Ridge. ("Karst" refers to a type of topography that is formed in carbonate rocks by dissolution and that is characterized by sink holes, caves, springs, and underground drainage.)

The Cumberland Plateau rises about 1,000 to 1,500 feet higher than the adjoining Valley and Ridge Province and Highland Rim. It extends about 175 miles, ranging northeast to southwest across central Tennessee. The bedrock is a sequence of near horizontal Pennsylvanian sandstones, shales, conglomerates, and coals, underlaid by Mississippian and older shale and carbonates. The area underlaid by the resistant Pennsylvanian sandstones has produced a "table-top" landscape. Groundwater usually occurs in areas of shallow, sandy soils and in deeper cracks in the bedrock. At depth, the Mississippian carbonates possess mature Karst features. Sinkholes, large caves, sinking streams, and springs typify the landscape, resulting in a complex aquifer system. Rapid groundwater movement is typical.

The Highland Rim section of the Interior Low Plateaus province presents a gently rolling plateau that occupies much of central Tennessee and parts of Kentucky and northern Alabama. The bedrock of the Highland Rim is flat-lying Mississippian carbonates. These formations constitute the most extensive aquifer in the Tennessee region. The Mississippian formations weather to form a deep flinty overlay typically exhibiting a rubble zone at the interface of the soil and bedrock. In places this overlay may rest directly on Chattanooga shale, which

serves as an aquitard. In many places the carbonate bedrock transports groundwater rapidly. However, in the broad dissected highlands, streams barely cut into the overlay and therefore have little effect on the discharge of water.

The Central Basin (Nashville Basin) of the Interior Low Plateaus province is an oval area in middle Tennessee lying about 200 feet below the surrounding Highland Rim. The bedrock is carbonate rocks that are generally flat-lying but are locally folded. Soil cover is usually thin, and surface streams cut into bedrock. Groundwater usually occurs in areas of carbonate rock that have been dissolved by water and in cracks in bedrock. The lack of unconsolidated overlay, along with open joints in rock, allows rapid runoff and infiltration of precipitation. Water is briefly stored above stream level and rapidly discharged to streams and springs through solution openings. As a result, small streams respond quickly to precipitation and have poorly sustained base flows.

The Coastal Plain province extends along the western edge of the region, and the Tennessee River flows along the eastern boundary against the edge of the Highland Rim. The major aquifers of the Coastal plain section lie in unconsolidated formations. They are of alluvial origin and consist of a heterogeneous assemblage of gravels, sands, silts, and clays. Occurrence of groundwater in the alluvial aquifers depends, in part, on the thickness of the formation and hydraulic characteristics of media composing the aquifer.

SOILS

A complex and diverse mosaic of soils reflects the great contrasts in geology and topography in the TVA region. Typically, the valley and river bottom soils are quite fertile and are used primarily for agriculture. In contrast, the forested ridges and mountains often have soils which have been highly leached and are therefore less fertile.

Impacts/Acidic Deposition and Deposition of Nitrogen

Current levels of acidic deposition are not thought to have significant impacts on the soils of the TVA region, with the exception of those in the higher elevations in the eastern portion of the region (Irving, 1991). TVA's contribution to acidic deposition is discussed earlier in Section 2 of this document (Volume 2, Technical Document 1, Comprehensive Affected Environment). Higher inputs of acidic deposition could accelerate depletion of base nutrients beyond the soil's natural ability to replenish them in soils with low buffering capacities and nutrient levels. Nutrient deficiencies could eventually occur and adversely impact forest productivity. As soil acidifies, toxic metals, such as aluminum, become more mobile and can damage plant roots. Fish and other aquatic life may be affected when aluminum is leached from the soil into surface waters. Other metals such as lead, cadmium, and zinc are also considered toxic and may be mobilized as soil acidification continues. Soil acidification and its associated impacts are of particular concern in the Great Smoky Mountains National Park, located in the eastern portion of the Energy Vision 2020 study area, and in Class I wilderness areas.

In some instances, acidic deposition can be beneficial to soils and plants through its fertilizing effects. Sulfur and nitrogen, essential plant nutrients, are often found in limited concentrations or unavailable forms in the soil. Studies have shown that atmospheric inputs of these elements can meet specific crop needs. Nitrogen, an essential element required by all plants will generally have a positive impact in most Tennessee Valley forests; however, it can become detrimental when present in excessive amounts, especially in high elevation forests. Excess nitrogen in high elevation forests can trigger adverse physiological changes within certain plants and can contribute to soil acidification. TVA's contribution of nitrogen oxides is discussed earlier in Section 2, Air Resources of this document (Volume 2, Technical Document 1, Comprehensive Affected Environment).

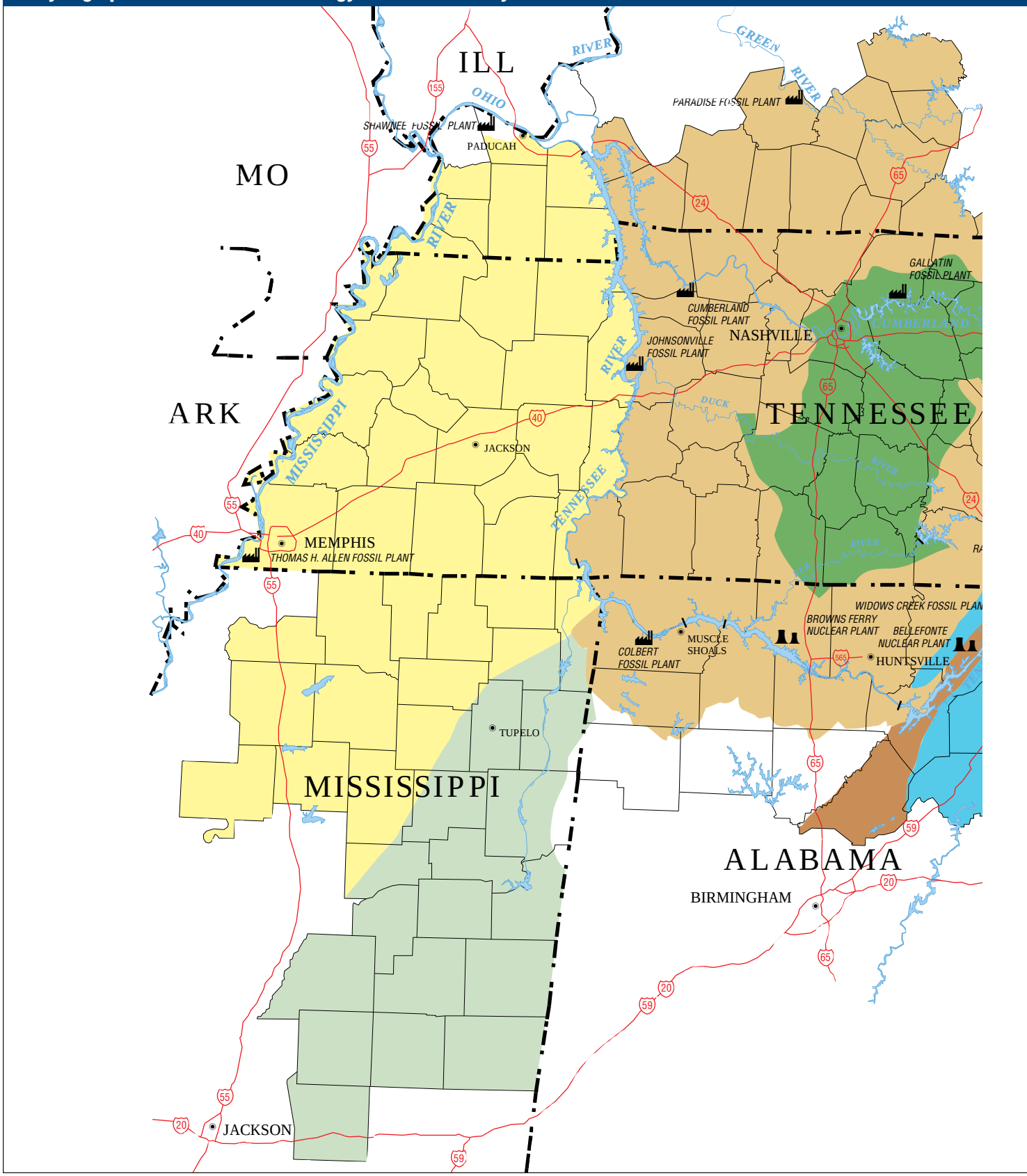
Soil Erosion

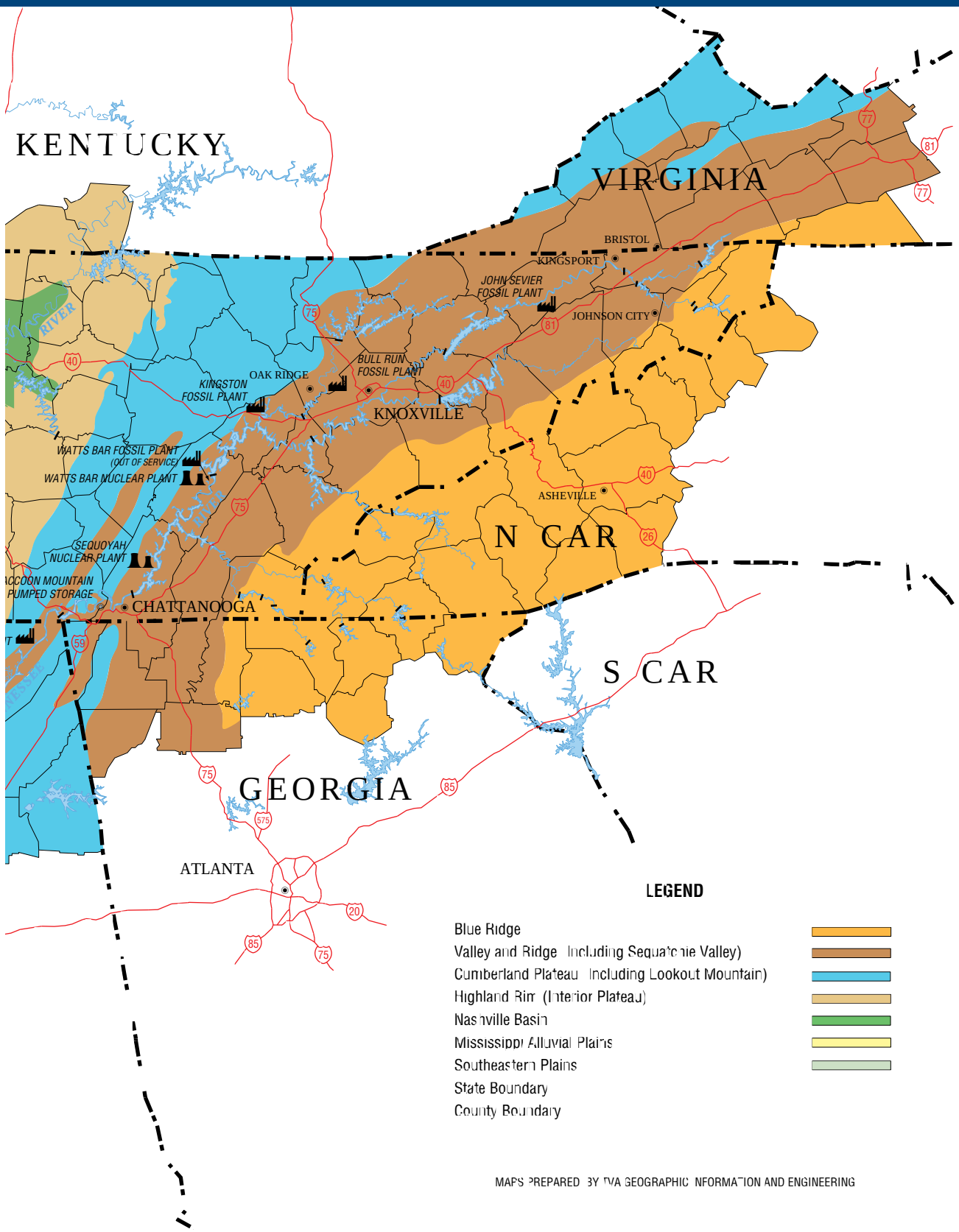
As in all areas inhabited by man, resource problems do exist. Erosion from all land uses in the region due to water or runoff is estimated to be 187 million tons annually (NRI 1982). Eighty-four percent of the erosion is considered to exceed tolerance levels for sustaining present land uses established by the Natural Resource Conservation Service.

Regionally, cropland has the largest percentage of land with excessive erosion. Cropland acreage represents approximately one-fourth of the region, and 51 percent of this acreage is estimated to be eroding at rates exceeding tolerance. This excessive erosion can be linked to the extreme vulnerability of the region's soils to the loss of productivity, which in turn affects farm income.

Some of the coal used to fuel TVA's power plants comes from surface mining. TVA's coal usage is discussed in Volume 2, Technical Document 2, Environmental Consequences. Soil erosion resulting from surface mining remains a concern for some parts of the region. Although production techniques have improved greatly, surface mining still promotes soil degradation and erosion to some extent.

FIGURE T1-67. **The Surface Geography Shown as Physiographic Provinces for the Energy Vision 2020 Study Area**




KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
BULL RUN FOSSIL PLANT
OAK RIDGE
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
ACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
S CAR
GEORGIA
ATLANTA
LEGEND
Blue Ridge
Valley and Ridge (Including Sequatchie Valley)
Cumberland Plateau (Including Lookout Mountain)
Highland Rim (Interior Plateau)
Nashville Basin
Mississippi Alluvial Plains
Southeastern Plains
State Boundary
County Boundary
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

Agricultural Lands

INTRODUCTION

Crops in the TVA region can be either positively or negatively affected by emissions from TVA power plants. Section 2, Air Resources in this document (Volume 2, Technical Document 1, Comprehensive Affected Environment) contains a discussion of potential effects.

Small farms that grow and market a wide diversity of agricultural products characterize agriculture in the Tennessee Valley. This region encompasses a wide range of soil types and properties. They range from the delta soils of the western region, producing abundant row crops, to the mountainous topography of the east, dotted with small farms producing a variety of traditional crops and high-income products such as Christmas

FIGURE T1-68. **U.S. Crop Production Rankings of States in the TVA Region**

	TVA REGION STATES						
Crops	**Alabama**	**Georgia**	**Kentucky**	**Mississippi**	**North Carolina**	**Tennessee**	**Virginia**
GRAINS							
Rice (All)				5			
Corn (Sweet)		9					
Rye		2			4		
VEGETABLES							
Tomatoes (F)		6				8	5
Tomatoes (P)							
Cucumbers (F)		4			9		7
Cucumbers (P)					3		
Lima Beans (F)		2					
Snap Beans (F)		4			8	5	9
Snap Beans (P)						9	
Onions (F)							
Watermelons (F)		5			9		
Cantaloupes (F)		5					
Bell Peppers (All)			8		7		10
Cabbage (F)		4			9		8
Spinach (F)							6
Sweet Potatoes	6	7		5	1		10
Spring Potatoes	6				3		
Summer Potatoes							5
FRUITS AND NUTS							
Strawberries (All)					9		
Blueberries		6			4		
Peaches (Freestone)		3			8		9
Grapes (All)		10					
Apples (All)					7		6
Pecans	4	1		7	10		
Peanuts	3	1			4		7
OTHER							
Hay (non-Alfalfa)			3			4	
Tobacco (All)		6	2		1	3	5
Cotton (All)	9	7		3	10	8	

Note: (F) = Fresh, (P) = Processed, (All) = Fresh and Processed.
Source: USDA National Agricultural Statistics Service (NASS), 1993.

trees, tobacco, vegetables, and other specialty crops. Farm sales in the Tennessee Valley have shifted from a predominantly row-crop agriculture to one that is more balanced. Forest products have increased in importance.

A minimal portion of prime farmland could conceivably be affected by building new power plants. Any future site-specific environmental reviews for power plant siting would assess any impact to prime farmland. The major impact is conversion to industrial/residential uses associated with urban growth. Power plants can affect urban growth by supporting new industry location to the region.

AGRICULTURAL LANDS AND CROP PRODUCTION

The Tennessee Valley region is a predominantly rural area with 40 percent of the land area in crop production or pasture and hay, and 55 percent in forest cover. Major crops produced in the region are tobacco, corn, cotton, soybeans, and wheat. (See the table in *Figure T1-68.*) With the exception of wheat, average yields of these major crops in the region have been consistently below the national average. While average yields are generally increasing for major crops, the rate of increase does not appear to be as great within the region as it is nationwide. The region is also a major production area for poultry broilers as well as non-poultry livestock. (Arkansas ranks number one, Georgia ranks number two, and Alabama ranks number three, with major growing areas in Kentucky and Tennessee.)

PRIME FARMLAND

Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses. It combines favorable soil quality, a good growing season, and adequate moisture. It produces the highest crop yields with the least amount of fuel, fertilizers, and labor. About 14 million acres of prime farmland occupy the Tennessee Valley region, with 55 percent crop land, 23 percent pasture, 20 percent forest, and 2 percent nonagricultural. This is about one-fourth of the region's non-federally owned land. The proportion of prime farmland is highest in the western portion of the region and lowest in the eastern portion. Under careful management, it can be farmed continuously without harming the environment or the resource base. According to the 1992 National Resource Inventory, there are 19,793,200 acres in the TVA 201-county region of prime farmland (48% cropland, 22% pasture land, 23% forest land, and 6% non agricultural use).

Agricultural Lands and Energy Crops

Energy crops include short rotation and woody crops that potentially could provide fuel for power plants. If enough energy crops were grown, other crops could be displaced. In 1993, Oak Ridge National Laboratory published a study, "The Potential Supply and Cost of Biomass from Energy Crops in the TVA Region," that concluded agricultural land in the TVA region could potentially support 18,000 megawatts of capacity fired by wood or 30,000 megawatts of capacity fired by switchgrass. This is more than the total additional capacity needed by TVA during the planning period for Energy Vision 2020.

Forest Resources

Forests in the TVA region can be affected by emissions from power plants. Section 2 in this document (Volume 2, Technical Document 1, Comprehensive Affected Environment) contains discussion of potential effects. The information used to produce the data in this section was obtained from U.S.D.A. Forest Service Experiment Station statewide forest inventories (Alabama, 1990; Georgia, 1989; Kentucky, 1988; Mississippi 1987; North Carolina, 1990; Tennessee, 1989; and Virginia, 1992). These inventories use a sampling scheme combining a forest-nonforest classification of points on aerial photographs with measurements on forested locations at the intersection of a sampling grid. At these locations, per-acre estimates are obtained from measured trees. Each forested sample point represents from 3,000 to 7,000 acres of forest.

FOREST LANDS

The 201 counties of the Tennessee Valley region contain 58.3 million acres. Fifty-three percent of the area is forested *(Figure T1-69).* Reserved forest land, consisting of parks, wilderness areas, and other forested lands specifically withdrawn from commercial timber cutting by legislation or administrative designation, totals 944,976 acres. The remainder of the forested area, 30 million acres, or 97 percent of the forest, is classified as timberland. The following sections examine this timberland.

Non-industrial private landowners own 76.8 percent of the timberland; forest industries control 9.3 percent. Public holdings total 4.3 million acres or about 14 percent. National forests located mainly in the southern Appalachian region on the eastern edge of the TVA study area account for about 62 percent of public timberlands.

FOREST TYPES

The forest type classifications are derived from the frequency with which a species or combination of species occurs on the timberland of an area. The primary forest type in the 201-county area is the oak-hickory forest type (64 percent), followed by the loblolly-shortleaf type and the oak-pine type (14 percent each). Other forest types including oak-gum-cypress, elm-ash-cottonwood, maple-beech-birch, and white pine-hemlock (less than 9 percent).

FOREST INVENTORY

The total standing inventory of live trees 5 inches in diameter or larger is 1,447 million green tons, including growing stock and rough and rotten trees. "Growing stock" refers to wood from live trees of traditional commercial quality. "Rough and rotten trees" are of less than usual commercial quality. These two classifications may be further divided by species group into hardwood and softwood. The hardwood growing stock in the affected area is 1,033 million green tons or 91 percent; rough and rotten trees total 99 million tons or 9 percent. Softwood growing stock totals 310 million green tons (98 percent), and softwood rough and rotten totals 5 million tons (2 percent).

Among growing stock species, yellow-poplar *(Liriodendron tulipifera)* is the most common individual species (9.8 percent of total volume) followed by white oak *(Quereus alba)* (9.3 percent) and loblolly pine *(Pinus taeda)* (8.1 percent). Among hardwood groups, the oaks *(Quercus spp.)* total 37 percent of the inventory and hickory *(Carya spp.)* 7.9 percent.

GROWTH AND HARVESTS

Ideally, in order for forests to be sustainable, the volume harvested should not exceed forest growth. It is important to examine the relationship of growth and harvests (also referred to as removals) within the 201-county Tennessee Valley region.

FIGURE T1-69. **TVA Region Forest Statistics**

	Volume (Cubic Feet)	
Growing Stock	41,826,310	
Growing Stock Hardwoods	32,161,815	
Growing Stock Softwoods	9,664,495	
Rough & Rotten Stock	3,224,914	
Rough & Rotten Hardwoods	3,071,501	
Rough & Rotten Softwoods	153,413	
All Trees	45,051,224	
Hardwoods	35,233,316	
Softwoods	9,817,908	
Growth		
Total	1,429,355	
Hardwoods	1,016,785	
Softwoods	412,570	
Removals		**Ratio**
Total	870,641	1.64
Hardwoods	500,332	2.03
Softwoods	370,309	1.11
		Rate
Net Change	558,714	1.24%
Hardwoods	516,453	1.61%
Softwoods	42,261	0.44%

	Area	
	Acres	Percent of Total
Land Use		
Nonforest Land	26,375,886	45.22%
Timberland	31,005,678	53.16%
Other Forest	944,976	1.62%
Total	58,326,540	100.00%
Ownership		
National Forest	2,673,559	8.62%
Other Public	1,652,496	5.33%
Forest Industry	2,874,900	9.27%
Farmer	7,723,525	24.91%
Misc. Private	16,081,198	51.87%
Total	31,005,678	100.00%
Forest Type		
White Pine-Hemlock	282,626	0.91%
Spruce-Fir	13,130	0.04%
Longleaf-Slash	11,359	0.04%
Loblolly-Shortleaf	4,260,862	13.74%
Oak-Pine	4,221,778	13.62%
Oak-Gum-Cypress	1,712,320	5.52%
Oak-Hickory	19,933,723	64.29%
Elm-Ash-Cottonwood	141,722	0.46%
Maple-Beech-Birch	428,158	1.38%
Total	31,005,678	100.00%

Data for growing stock trees were obtained from the U.S. Forest Service inventories and does not include the effects of any harvests started after the last periodic inventory. Data for harvests indicate the average annual removal of timber from timberland since the time of the last survey (usually 7 to 9 years).

For the total growing stock resource in the 201-county area, net annual growth totals 51.3 million tons and estimated annual harvests total 31.3 million tons. Thus, annual net change in the area is 20 million tons. The net change rate (net change volume/growing stock inventory) is 1.3 percent per year.

Another measure for comparing growth and harvests is the growth/drain ratio. It is derived by dividing the volume of growth by the volume of harvests. For example, if the growth/drain ratio is 1.0, growth and harvests are in balance. In the 201-county area, the growth/drain ratio of all growing stock is 1.6.

Examining these statistics by species group can provide more insight on the changes taking place. In the TVA region, softwood growing stock growth is 14.8 million tons and harvests are 13.3 million tons, for a net change of 1.5 million tons. The growth/drain ratio is 1.1. In comparison, the annual growth for hardwoods is 36.5 million tons, and annual harvest totals 17.9 million tons, resulting in a net change of 18.6 million tons. The net change rate is 1.6 percent, and the growth/drain ratio is 2.0.

Class I Air Quality Areas

The Clean Air Act gives special protection to national parks and national wilderness areas. These areas are designated "Class I Areas" and air quality is regulated within their boundaries. According to EPA regulations, air pollution effects constitute an unacceptable adverse impact in Class I Areas if they meet any of the following criteria:

- Diminish the national significance of the area
- Impair the quality of the visitor experience
- Impair the structure and function of the ecosystem.

Federal land managers are required to assess air quality in Class I Areas and determine possible impacts of air pollutants on resources.

There are seven Class I Areas in the Tennessee Valley region, as shown in the map in Figure T1-18 (U.S. EPA 1993). These Class I Areas include Sipsy, Alabama; Cohutta, Georgia; Mammoth Cave, Kentucky; Joyce Kilmer/Slickrock, North Carolina; Linville Gorge, North Carolina; Shining Rock, North Carolina; and the Great Smoky Mountains, Tennessee/North Carolina. An additional class 1 area, the Mingo National Wilderness Area is just outside the TVA region in Missouri.

Cultural Resources

Potential impacts to cultural resources can be caused by construction of power plants, air pollutants, and by coal and uranium mining and provision of biomass fuels for power plants. Although air quality can negatively impact cultural resources within the TVA region, these potential impacts are for the most part insignificant and can generally be managed or mitigated.

A more direct potential impact to cultural resources is the procurement of fossil and biomass fuels. Strip mining for coal (fossil fuel) can impact both archaeological sites and historic structure resources. Timber harvesting (biomass fuel) can also impact archaeological sites and standing structures. Increased use of biomass fuels may also lead to changes in land use patterns through the establishment of more corporate-owned tree plantations, which can lead to the abandonment or destruction of historically or architecturally important farm complexes.

Future site-specific environmental reviews for power plant siting would assess any impacts to cultural resources and archaeological sites.

The Tennessee Valley region is renowned for its numerous archaeological sites. The National Historic Preservation Act requires all federal agencies to identify, protect, and manage significant cultural resources on their land or those affected by their undertakings whether on federal or nonfederal property. Cultural resource management is concerned with maintaining the integrity of significant archaeological remains, man-made structures or features, and sites of historical importance.

Recreational Resources

Recreational resources can be affected by power plant emissions leading to visibility impairment, by water releases for hydroelectric power production, and by other activities that could result from the selection of future resources in Energy Vision 2020. The Tennessee Valley region affords diverse scenic and outdoor recreation resources. The lakes, rivers, and mountains of the region provide a wide variety of outdoor recreation activities including fishing, skiing, swimming, hiking, hunting, wildlife observation, sightseeing, and camping and are dependent upon clean water and healthy, diverse flora and fauna. Public lands including national parks and monuments, national forests, TVA lands, and state parks and forests provide significant recreation opportunities. These public lands, as well as private lands, also provide an aesthetic "backdrop" for recreation and tourism activities in the region. Significant river-based recreation resources are provided as shown in *Figure T1-70.* The TVA reservoirs named in *Figure T1-63* are also significant river-related recreation

resources. A complete listing of natural areas can be found in the 18 Categories of Natural Areas Appendix at the end of this document.

In the 1980s, the South accounted for more than half of the nation's population growth and is expected to be one of the dominant growth regions into the twenty-first century. As a growing portion of the United States population leaves the active labor force, growth of retirement centers and associated travel in the South and Southwest may increase even more rapidly than in the past. Travel and tourism present significant and growing contributions to the economic activity in the Tennessee Valley region. In 1991, travel and tourism accounted for 126,000 jobs, about 5.5 percent of non-farm employment.

FIGURE T1-70. **Designated River Recreation Resources in the TVA Region**

Wild and Scenic Rivers	National Recreation Rivers
Obed-Emory Rivers (Tennessee)	Big South Fork River (Tennessee/Kentucky)
Horsepasture River (North Carolina)	Chattahoochee (Georgia)
New River & South Fork New River (North Carolina)	
Chattooga River (South Carolina/Georgia)	
Sipsey River (Alabama)	
Black River (Mississippi)	

Other Land Use Conditions

ELECTRIC AND MAGNETIC FIELDS

Implementation of Energy Vision 2020 strategies for the future may result in the construction of new transmission lines and in the installation of energy-efficient electrical appliances. Either of these activities could result in the production of electric and magnetic fields (EMF). EMF arises from both nature and human activity. For example, the earth and individual human beings produce direct current magnetic fields. Lightning is an extremely powerful electric charge. Human-produced EMF can be caused by direct current, such as the voltage from batteries, or alternating current, such as the voltage from most electric power lines in the United States. Every device that generates, transmits, or uses electricity produces electric and magnetic fields. This list includes electric appliances, motor vehicles, and electric wiring. There is no place on earth where an individual is not exposed to EMF. In modern societies, individuals are exposed to varying levels of EMF throughout their daily activities.

EMF from electric devices and power lines is generally much weaker than that produced by the human body itself and is usually too small to be noticed (Carnegie Mellon University 1989). Because this induced EMF is weak, scientists thought for many years that it had no adverse health effects. However, a 1979 epidemiological study suggested a potential link between magnetic fields associated with electric distribution lines and childhood leukemia (Bonneville Power Administration 1989). After 15 years of research, the results have been mixed. A few additional studies have suggested similar links to various forms of cancer, particularly studies of EMF exposures in occupational settings. Other studies have found no such links and no studies have yet found a cause-and-effect relationship. If EMF does pose a risk, most researchers believe the risk is low, and most scientists familiar with the issue agree that more research into the effect of EMF on health is needed. It is likely to be many years before more definitive conclusions can be reached.

High-voltage power lines have been the subject of much of the research into the potential health effects of EMF. Transmission lines are the means by which TVA-generated power reaches distribution points. When a new supply-side resource is added to the TVA system, it must be connected to the TVA transmission system. A supply-side resource built at a new plant site would require new transmission lines and possibly result in additional population exposures to EMF. In addition, other resource options, such as those involving dispersed power generation, may result in increased population exposures since they are usually built in more populated areas.

No federal regulations govern EMF exposure levels. A few states have established guidelines or standards for electric field levels. Two states, New York and Florida, have magnetic field standards. Some municipalities have established electric or magnetic field standards. None of the states in which TVA operates have set or proposed EMF standards.

TVA adopted interim guidelines in 1993 that address EMF exposures. Under these guidelines, TVA will take into account EMF exposure when planning new transmission lines. Whenever practical, TVA will route new lines to avoid homes, schools, and other densely populated areas. In addition, TVA will design new transmission lines and upgrades of existing lines to reduce EMF levels.

COAL PROCUREMENT

The amount of coal purchased by TVA and whether it comes from underground or surface operations can have differing environmental effects. Site-specific environmental impact reviews will address TVA fuel requirements in some detail.

Most of TVA's fossil plants are located near two major coal-producing regions. These regions are the southern Appalachian region, which includes eastern Kentucky, Virginia, West Virginia, Tennessee, northern Georgia, and northern Alabama; and the eastern interior region, including western Kentucky, southern Illinois, and southern Indiana. TVA purchases about 35 to 40 million tons of coal annually to fuel its 11 operating fossil plants.

TVA's eastern coal procurements are about 7.1 percent of the eastern United States production (east of the Mississippi River) and about 0.36 percent of the western United States production. The maps in *Figures T1-71* and *T1-72* show the location and intensity of TVA coal procurement in the eastern and western United States by county for fiscal year 1994. The table in *Figure T1-73* gives TVA the amount and percent of coal procurement by state.

The acquisition of low-sulfur western coal serves as one component of the compliance strategy for sulfur dioxide emission reductions required under the Clean Air Act amendments of 1990. In fiscal year 1994, 1.59 million tons, or 4.2 percent of coal procurements, were from western states. For the 1995 to 2000 period, the estimate for annual procurement of western coal is 4.2 million tons. In fiscal year 1994, 6.5 million tons of coal were procured from surface mines, 17 from underground mines, and the source of 14.3 tons was either surface or underground mines.

Land-related environmental impacts of mining are primarily the direct and indirect impacts of changes in land use. Past impacts have included acid drainage from exposed sulfur-bearing rock, erosion from disturbed mining areas and coal transport roads, loss of wildlife habitat, deforestation, stream siltation, unstable land situations, and fugitive dust; however, the Surface Mining Control and Reclamation Act (SMCRA) now addresses these issues in permitting enforcement. Other land-related mining impacts can include loss of prime farm land, encroachment on threatened or endangered species, and loss of cultural and archaeological resources.

FIGURE T1-73. **TVA Coal Procurement by State**

State	FISCAL YEAR 1994 Thousands of Tons	Percent
Colorado	1,196	3.2
Illinois	3,907	10.3
Kentucky	27,091	71.7
Ohio	213	0.6
Pennsylvania	567	1.5
Tennessee	1,008	2.7
Utah	365	1.0
Virginia	1,282	3.4
West Virginia	2,118	5.6
Wyoming	29	0.1
Total	**37,776**	**100.0**

Mines in the southern Appalachians are often developed on lands which are not well suited to agriculture. Ideally, commercial timber is harvested and marketed prior to excavation for mining. Aesthetics is another potential environmental concern. Mining operations usually clash with the surrounding landscape, and in the case of high elevation ridge-side or ridge-top surface mining, the operation may be visible for many miles, either as a distinct feature or as a disruption of the skyline. Mine reclamation requires restoration to original contour, and appropriate re-vegetation can mitigate long-term visual aesthetics impacts, as well as impacts resulting from changes in land-use.

Mining in the eastern interior region is more likely to involve either agricultural or forested lands. Long-range visual aesthetic impacts are less likely to be significant because of topography.

COAL COMBUSTION SOLID WASTES

The amount of coal used as fuel is related to the solid waste produced. The combustion of pulverized coal in power plant boilers produces solid wastes as fly ash and bottom ash (or boiler slag in some boiler designs). The primary constituents of ash and slag are silica (SiO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3). Flue gas desulfurization by wet limestone scrubbers for environmental control produces a gypsum sludge ($CaSO_42H_2O$) solid waste. Coal washing residue creates another waste. Any of these wastes may be marketed as byproducts depending on their quality and market conditions.

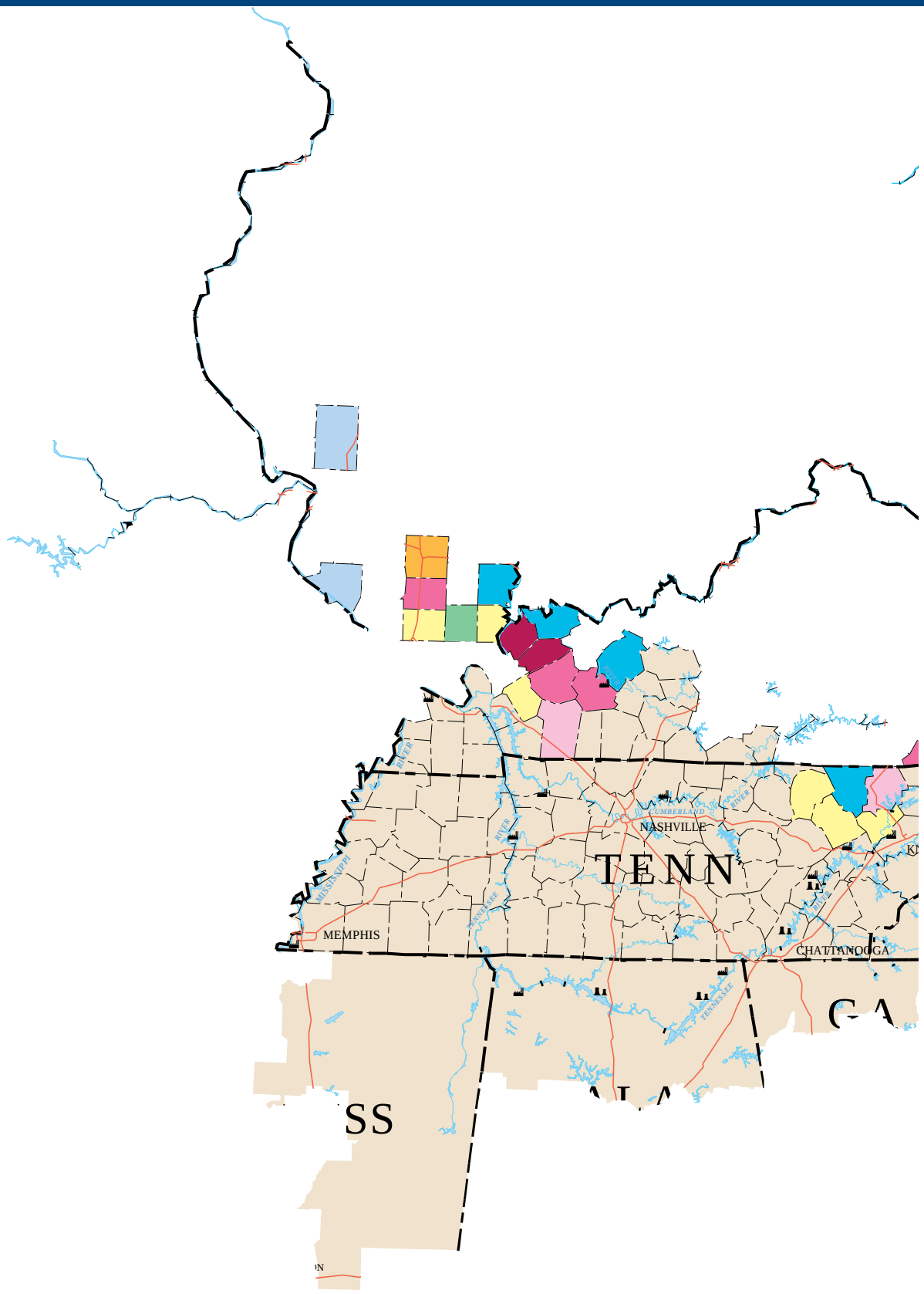
TVA coal-fired plant production of these byproducts during fiscal year 1994 is listed in *Figure T1-74*. TVA's total coal combustion byproduct utilization from 1989 to 1994 is summarized in *Figure T1-75*. Selected coal combustion byproduct usage is shown in *Figure T1-76*. The total production of byproducts was nearly 6 million tons with almost half being fly ash. Bottom ash/slag, flue gas desulfurization, and gypsum sludge accounted for 20 percent each.

The remainder of the byproducts is either disposed of or stored on the plant site in ash ponds or dry-stacked landfills. The liquid waste discharges from ash ponds are permitted according to the National Pollution Discharge Elimination System. At some plants, possible groundwater contamination is monitored by sampling groundwater in the nearby area.

URANIUM PROCUREMENT

The natural uranium for TVA's nuclear plants comes from uranium producing areas all over the world. The world's major ura-

FIGURE T1-71. **TVA Procured Coal from Seven Eastern States in Fiscal Year 1994**



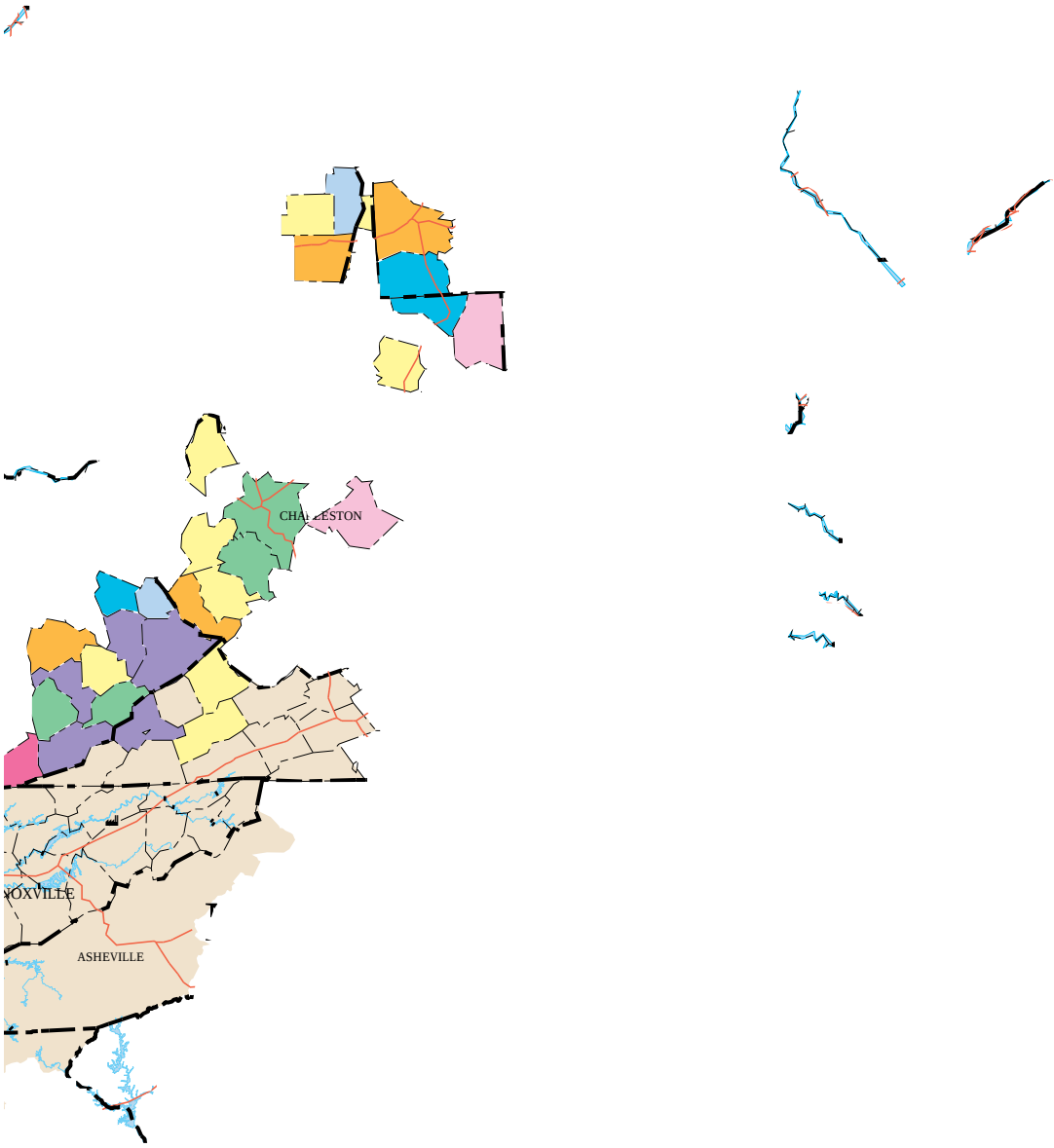
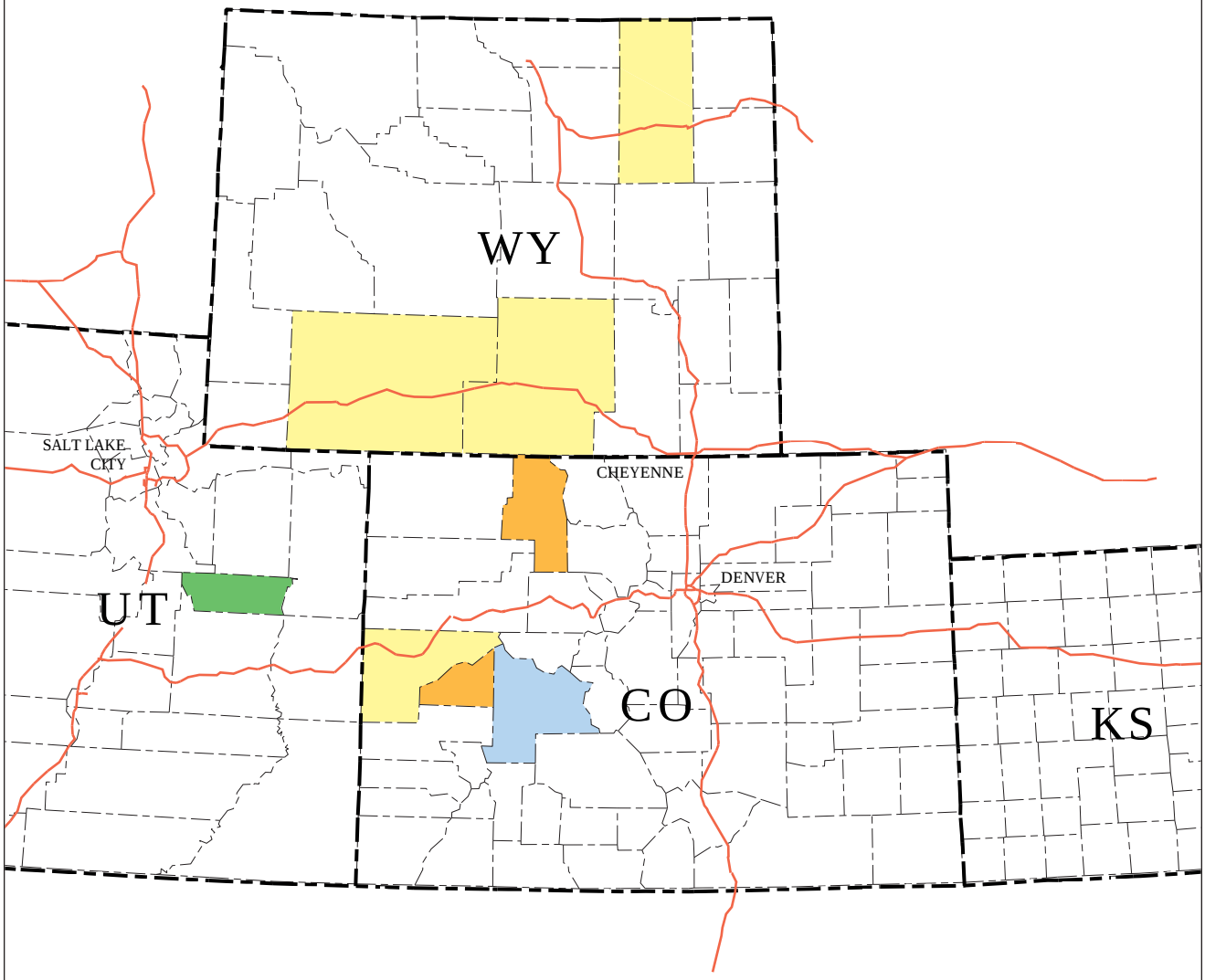

CHARLESTON
ASHEVILLE

FIGURE T1-72. **TVA Procured Coal from Three Western States in Fiscal Year 1994**



LEGEND

TVA WESTERN COAL PROCUREMENT

- 0 Tons
- 50,000 Tons
- 75,000 Tons
- 100,000 Tons
- 300,000 Tons
- 500,000 Tons

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-74. TVA Coal Combustion Byproduct Production, Fiscal Year 1994

	COAL		BYPRODUCT			
Plant	Coal Burn (Tons)	Coal Ash (%)	Fly Ash (Tons)	Bottom Ash/Slag (Tons)	Gypsum (Flue Gas Desulfurization Sludge) (Tons)	Coal Wash (Tons)
Allen	2,023,847	8.31	42,045	126,136		
Bull Run	2,119,542	8.79	158,362	27,946		
Colbert (1-4)	1,826,608	11.59	169,363	42,341		
Colbert (5)	1,158,004	9.92	91,899	22,975		
Cumberland	5,766,501	10.26	473,314	118,329	964,577	
Gallatin	2,522,861	7.99	161,261	40,315		
John Sevier	2,047,223	11.53	188,836	47,209		
Johnsonville	3,555,731	10.01	284,743	71,186		
Kingston	3,925,284	8.94	280,736	70,184		
Paradise (1-2)	3,482,965	8.74	76,103	228,308	559,631	539,860
Paradise (3)	2,020,667	8.57	43,293	129,878		313,203
Shawnee (1-9)	3,302,792	10.13	267,658	66,915		
Shawnee (10)	380,970	7.28	137,239	43,857		
Widows Creek (1-6)	1,629,437	10.29	134,135	33,534		
Widows Creek (7)	1,162,420	11.01	102,386	25,596	221,886	
Widows Creek (8)	1,474,021	10.87	128,181	32,045	400,346	
TOTALS	**38,398,872**		**2,739,555**	**1,126,754**	**2,146,440**	**853,063**

FIGURE T1-75. TVA Coal Combustion Byproduct Utilization, Fiscal Years 1989 to 1994

Fiscal Year	Utilization (Tons)
1989	487,309
1990	625,761
1991	770,921
1992	1,038,244
1993	701,822
1994	1,176,568

FIGURE T1-76. Selected Coal Combustion Byproduct Uses

	BYPRODUCT			
Byproduct Use	Fly Ash	Bottom Ash	Boiler Slag	Flue Gas Desulfurization Sludge
Cement/Concrete Products	X	X	X	X
Asphalt Products		X	X	
Roofing Granules			X	
Roadbed, Road Surfacing, Embankments	X		X	
Grit for Snow/Ice Control		X	X	
Blasting Grit			X	
Landfill and Structural Fill	X	X		
Gypsum Wall Board				X

nium producing countries are Canada, Australia, South Africa, Niger, Russia, Namibia, Uzbekistan, Tajikistan, Kazakhstan, and the United States. Current annual world production is approximately 80 million pounds of U3O8. TVA's five nuclear units use a total of about 2.5 million pounds of U3O8 per year. TVA currently has sufficient inventory to last until 1999.

Much of the world's uranium is produced in dry, arid thinly populated areas like the southwestern United States and the Australian outback. Mining methods range from open-pit mining to deep-pit mining to low impact leaching operations. Environmental management is an integral part of overall mining operations. Extensive monitoring programs are implemented. One of the main objectives of environmental plans is to return as much of the mining site to its former state as possible once mining operations are completed. Decommissioning plans are made, funded, and implemented.

After mining, the natural uranium is transported to either of the two conversion plants located in Illinois or Ontario, Canada, for further refinement and processing. Subsequently, the natural uranium is typically shipped to one of the federal government's uranium enrichment plants located at Paducah, Kentucky or Portsmouth, Ohio. TVA receives its nuclear fuel in the form of fabricated nuclear fuel assemblies in which the uranium has been encapsulated in metal tubes.

TVA and a number of other United States utilities are expected to soon be using commercial grade slightly enriched

uranium derived from nuclear warheads in the true sense of swords to plowshares. Under this program, the highly enriched uranium obtained from both United States and Russian nuclear warheads will be diluted to low levels, which allows its use in commercial nuclear plants. A substantial reduction in the quantity of nuclear warheads in the world is a major benefit to the environment and mankind.

NUCLEAR WASTE

Introduction

The nuclear fuel used for power plants produces radioactive solid wastes requiring storage and disposal. These wastes are placed in two categories: low-level radioactive waste and high-level radioactive waste. These indicate the type of radioactive material, the intensity of its radiation, and the time required for decay of the radiation intensity to natural levels.

High-Level Nuclear Waste

Background

Ninety-nine percent of high-level waste from commercial nuclear plants is used fuel that has released most of its energy. The fuel that runs nuclear power plants is made up of small uranium pellets. These are placed inside long metal fuel rods. These fuel rods are grouped together into fuel assemblies, which are placed inside a reactor. In the fission process, uranium atoms begin to split in a chain reaction, one after another. The fission process yields energy in the form of heat for power plant operation.

Certain changes take place in the fuel during the fission process. Most of the fission products—the nuclei left over after the atom has split—are radioactive. Over time, these trapped fission products reduce the efficiency of the chain reaction. Approximately every 18 months, the oldest fuel assemblies that have already released their energy are removed and replaced with fresh fuel. Operation of TVA's 5 nuclear units will produce about 115 metric tons of used fuel each year.

After it is removed from the reactor, used fuel is stored at nuclear plant sites either in pools (steel-lined, concrete vaults filled with water) or in dry casks (above-ground concrete or steel containers). The radioactive waste remains locked inside the uranium pellets which are still encased in the fuel rods. Used fuel has been stored safely at nuclear plant sites since the late 1950s, when the first nuclear energy plants began making electricity.

Within six months of fuel removal and storage at the plant site, 98 percent of the fuel's radiation has dissipated. Forty to 50 years after the spent fuel is removed from the reactor, its radioactivity has decreased to 1 percent of its initial radioactivity. A very small percentage of nuclear wastes remain radioactive for thousands of years.

Radioactive waste has been a prominent topic in the controversy over nuclear energy. Often the attention focuses on the disposal of spent fuel from nuclear reactors. Radiation has been studied for nearly a century, and scientists can detect even the smallest amount. Scientists and engineers believe they know how to safely isolate radioactive material underground so it will not pose a danger to current or future generations. A permanent repository with multiple barriers, both natural and man-made, is to be designed and built by the Department of Energy to ensure radioactivity does not escape and waste is isolated from the environment. Waste will be sealed in metal canisters and placed a half-mile or more underground in a stable geological environment.

The feasibility of underground waste repositories has been demonstrated in studies and test projects. Geologic repositories deep underground have been endorsed by independent scientific organizations around the world, including the National Academy of Sciences, the National Research Council, and the Congressional Office of Technology Assessment. Almost all other countries with a nuclear energy program, including Germany, France, and Japan, have determined that deep geologic disposal is the safest system of permanent nuclear waste management.

The Nuclear Waste Policy Act (NWPA) of 1982 established a program to build the nation's first underground high-level waste repository early in the next century. The act and its amendments charge the Department of Energy (DOE) with the following tasks:

- Locating, building, and operating a deep-mined geologic permanent repository for high-level waste
- Evaluating the need for a monitored retrievable storage facility—a short-term, continuously monitored facility for the interim storage of spent fuel
- Developing a transportation system that safely links United States nuclear power plants, the monitored retrievable storage, and the permanent repository.

In 1987, amendments to the Nuclear Waste Policy Act of 1982 designated the remote area of Yucca Mountain, Nevada, northwest of Las Vegas, for study as a possible permanent repository site. The Department of Energy has begun site characterization, the comprehensive scientific investigation of Yucca Mountain's suitability. The permanent repository facility must meet strict licensing requirements of the U.S. Nuclear Regulatory Commission. Additional oversight will be provided by the U.S. Environmental Protection Agency, the State of Nevada, and the Technical Review Board appointed by the President.

Concern about the transportation of high-level waste is another issue related to disposal. The federal government has established controls and regulations to ensure that radiation exposure from accidents does not occur under either normal or abnormal conditions. To date, there have been more than one million ship-

ments of radioactive materials, mostly for medical purposes, with a lower than average vehicle accident rate. No one has ever been injured due to radiation exposure from the 6,000 spent fuel assemblies transported to date in the United States.

Spent fuel is shipped in specially constructed casks, each of which must be licensed by the Nuclear Regulatory Commission (NRC). The casks must be able to withstand several severe shocks without leaking—a 30-foot drop onto a flat, unyielding horizontal surface with the cask oriented to cause maximum damage; a 40-inch drop onto the pointed end of a steel bar, also with the cask oriented for maximum damage; exposure to a 1,475 degrees F fire for 30 minutes with no artificial post-fire cooling; and immersion in water to a depth of three feet for at least eight hours immediately following the fire test. The Nuclear Regulatory Commission tests required to license shipping casks are more stringent than conditions the casks would be subjected to in actual accidents.

Below is a listing of other federal agencies involved in the management of high-level radioactive waste:

- The Environmental Protection Agency issues generally applicable environmental radiation standards effective outside the boundaries of sites that possess radioactive materials.
- The Nuclear Regulatory Commission develops and enforces regulations to protect the public health and safety from all domestic commercial nuclear activities. Rules on mined geologic repositories have been formulated that will specifically implement the general environmental standards set forth by the Environmental Protection Agency.
- The Department of Transportation governs the shipment of all privately owned radioactive materials, including nuclear waste, by all modes of transport. It also administers the labeling, classification, and marking of all radioactive waste packages.
- The Department of Interior through the U.S. Geological Survey cooperates with the Department of Energy on technical activities in the earth sciences, including geologic investigations in support of waste disposal.

Status of TVA Spent Fuel Storage

TVA plans to continue to store spent nuclear fuel on-site at plant locations where it is generated until the Department of Energy accepts physical custody by shipment off-site to a monitored retrievable storage facility or to a permanent underground repository for ultimate disposal by burial. TVA is currently storing some 760 and 417 metric tons of used fuel on site at Browns Ferry and Sequoyah Nuclear Plants, respectively. Current spent fuel storage capacity is sufficient at Sequoyah Nuclear Plant until 2004 and at Browns Ferry Nuclear Plant until 2007. Based on one-unit operation at Watts Bar Nuclear Plant, spent fuel storage capacity will be sufficient until 2018. TVA has sufficient outside site area at each of its nuclear facilities to store any high-level waste associated with decommissioning activities and life-of-plant quantities of used fuel. As the pools approach the current storage limits, TVA will initiate studies to increase on-site storage capacity.

Low-Level Nuclear Waste

Low-level radioactive waste consists of items that have come into contact with radioactive materials. Activities that use radioactive materials, and therefore produce low-level waste, include biomedical and pharmaceutical research, industrial processes, diagnosis and medical treatment, and nuclear-generated energy. In a nuclear energy plant, the low-level radioactive waste comes primarily from small particles in the internal reactor-cooling water that are captured in filters, deposited in valves and pumps, or collected on surfaces inside the plant. Many items such as filters, cloth and paper wipes, plastic shoe covers, tools and materials, water purification media (resins), and other residues collect varying quantities of radioactivity.

The radioactive particles in low-level radioactive waste emit the same types of radiation that occur in nature. About 90 percent of low-level radioactive waste fades away through radioactive decay into natural levels of radioactivity within 10 years. About 99.9 percent of it diminishes to natural levels in less than 300 years.

Low-level radioactive waste is measured by volume generated or volume disposed of, usually in cubic meters. Generators of low-level radioactive waste have worked to reduce the volume sent to disposal sites. TVA regularly compares its low-level radioactive waste volumes to the best and median volume generators in the nuclear industry. Low-level radioactive waste production at TVA nuclear plants is currently about 70 percent of the industry average. Reduction of waste volume is accomplished through a combination of on-site volume minimization and off-site volume reduction processes. Waste volume is reduced through compaction, incineration, and decontamination.

Low-level waste that is shipped to disposal sites travels by ground transportation in special boxes, drums, or steel containers designed to meet Nuclear Regulatory Commission and Department of Transportation standards for impact resistance. The type of container required depends on the amounts and types of radioactive elements in the waste. There has never been a serious transportation incident involving the disposal of radioactive material.

The purpose of low-level radioactive waste disposal is to isolate the waste from both people and the environment. Designs for building disposal facilities include shallow land bur-

ial, a below-ground vault, an above-ground vault, modular concrete canister disposal, and earth-mounded concrete bunkers. Although the disposal approach may vary, depending on the location, all disposal facilities use a series of natural and engineered barriers to prevent the radioactive material from reaching the environment. All of them meet strict federal and state requirements for isolating the waste until the radioactivity has faded to natural background levels.

In 1980, Congress passed the Low-Level Radioactive Waste Policy Act. That law requires every state to develop an adequate disposal site for its own waste or to form "compacts" with other states to provide regional disposal. The states participating in the Southeast Compact Commission have selected North Carolina as the host state to select, license, and construct a new disposal site. The current schedule calls for this facility to be complete in 1998. Until July 1995, the low-level waste generators located in the eight Southeastern states were required to dispose of their waste at the Barnwell, South Carolina disposal facility. In July, South Carolina withdrew from the Southeast Compact Commission in order to open the Barnwell facility to all states except North Carolina. Barnwell is expected to remain open to these users for another 7 to 10 years. TVA plans to continue to use the Barnwell facility for low-level radioactive waste disposal until the North Carolina facility is opened. Should either or both of the disposal facilities close unexpectedly, low-level radioactive waste will be stored in on-site facilities at the TVA nuclear plants. These facilities are sized to handle any anticipated storage needs for the foreseeable life of the plants.

Below is a listing of agencies involved in the regulation of low-level radioactive waste:

- The **U.S. Nuclear Regulatory Commission** licenses many of the facilities that produce low-level waste, including nuclear energy plants, and regulates low-level radioactive waste disposal.
- The **U.S. Environmental Protection Agency** develops general standards to protect the public from radiation.
- The **U.S. Department of Transportation** regulates the interstate shipment of privately owned radioactive materials.
- The **U.S. Department of Energy** coordinates national planning with the states for managing low-level radioactive waste.
- The **U.S. Geological Survey** offers technical assistance with studies of hydrology and geology of proposed sites.
- **State governments** are responsible for disposal of the low-level radioactive waste generated in their states or for joining a regional compact. State governments are responsible for selecting and licensing a site according to federal standards and monitoring its operation. Most states have licensing authority from the Nuclear Regulatory Commission for low-level waste disposal within their state.
- **The Nuclear Regulatory Commission** regulations cover the off-site disposal of low-level radioactive waste; the Nuclear Regulatory Commission and the U.S. Department of Transportation cover the transportation of waste; and the Nuclear Regulatory Commission regulations cover on-site storage.

Biological Resources

INTRODUCTION

Biological resources such as wetlands, wildlife, vegetation, sensitive ecosystems, endangered species, and unique natural areas can potentially be affected by dams, power plant emissions, and sites for power plants. The Tennessee Valley region contains a wide diversity of flora, fauna, and biological habitats. Biological resources of the Valley are summarized in this section.

TERRESTRIAL ECOLOGY

Wetlands

Wetlands are defined as lands that are covered by shallow water or with the water table near the surface. They support vegetation typically found in wet habitats, have soils wet enough to produce anaerobic conditions, and/or have a substrate saturated or covered with water at some time during the growing season (Cowardin et al. 1979). Although wetlands occur throughout the TVA region, they are most extensive in the south and west. There are two main types of wetlands—palustrine, or marshy, and lacustrine, formed by lakes (U.S. Fish and Wildlife Service National Wetland Inventory data). The most common palustrine types are forested wetlands (also the most extensive type in the TVA region), scrub-shrub wetlands, and emergent wetlands. The most common lacustrine wetland type is aquatic bed wetlands.

Over half of the wetland acreage that originally occurred in the seven states forming the TVA region has been lost (Dahl 1990). The major causes of wetlands loss are agricultural conversion, inundation by reservoirs, and conversion to urban or other non-agricultural land uses. The rate of wetland loss has slowed in recent years, and further destruction of wetlands is discouraged by Executive Order 11990, the North American Wetlands Conservation Act, and other regulations. Any future site-specific environmental reviews for power plant siting will consider wetlands in assessing potential impacts.

Wildlife

The TVA region contains portions of six physiographic regions (see the map in *Figure T1-67*) and a great variety of plant and

animal communities. About 70 species of mammals, 300 species of birds (including 175 that nest within the region), 65 species of reptiles, and 77 species of amphibians regularly occur in the region. Several salamander species are only found in the TVA region. Few other terrestrial vertebrate species are restricted to the TVA region.

Except for many birds, game species, and species listed as endangered or threatened (see species list at the end of this document in the Threatened and Endangered Species Appendix), little population trend information is available for terrestrial animals. Systematic censuses conducted since the mid-1960s show that populations of about 18 percent of the bird species nesting in the region are declining, while about 10 percent are increasing (Nicholson in press). About 30 percent of the bird species are encountered too infrequently by this survey to show population trends. The majority of the birds with declining population trends are species that nest in North America and winter in Latin America. Many of these species require large tracts of forest and are adversely affected by forest fragmentation resulting from land use changes such as road and power line construction and suburban and agricultural development. Several bird species that require early successional habitats, both permanent residents and long-distance migrants, also show a decline.

Twenty-two species of mammals and 34 species of birds are legally hunted or trapped in the TVA region. The population trends of these species in the region generally parallel their trends elsewhere, with northern bobwhite *(Colinus virginianus)* and most duck species declining, and white-tailed deer *(Odocoileus virginianus)*, wild turkeys *(Meleagris gallopavo)*, geese, and wood ducks *(Aix sponsa)* increasing.

Vegetation

The six physiographic regions within TVA's 201-county area contain approximately 4,300 species of herbs, shrubs, and trees in numerous habitats and plant communities. It also contains several non-forested plant communities, such as cedar glades, balds, remnant prairies, gravel bars, and cliff faces. These areas are extremely small compared to the extensive forests that characterize this region.

Based on an analysis of late successional forests, Braun (1950) recognized five major forest regions in the TVA region. *(*See *Figure T1-77.)* Three of these regions are further divided into sections, generally along physical geology boundaries. The major tree species in these regions are listed in *Figure T1-78*.

Local vegetation types vary greatly within Braun's divisions because of variation in elevation, relief, soil fertility, moisture, and the degree of human disturbance. The tree species composition of early to mid-successional forests (forests in the early to middle stages of their cycle) is fairly uniform across the TVA region on sites with similar environmental conditions. Red cedar *(Juniperus virginiana)* and mixed cedar types are common on reverting old fields and on sites with shallow, basic soils. Yellow pines (especially loblolly *[Pinus taeda]*, Virginia *[P. virginiana])* and shortleaf *(P. echinata)* are widespread and occur both in tree plantations and naturally in early successional stands. Oak-hickory forests, often mixed with yellow pines, are widespread on drier, upland sites. Bottomland hardwoods containing such species as oaks, sweetgum *(Liquidambar styraciflua)*, maples *(Acer spp.)*, and other wet-site hardwoods are typical of rich alluvial lowlands. Sugar maple *(Acer saccharum)* and American beech *(Fagus grandifolia)* frequently occur on rich, north slopes and, along with species such as hemlock *(Tsuga canadensis)*, northern red oak *(Quercus rubra)*, and basswood *(Tilia heterophylla)*, are common at higher elevations in the eastern portion of the region.

STRESSORS TO THE FORESTS OF THE TENNESSEE VALLEY

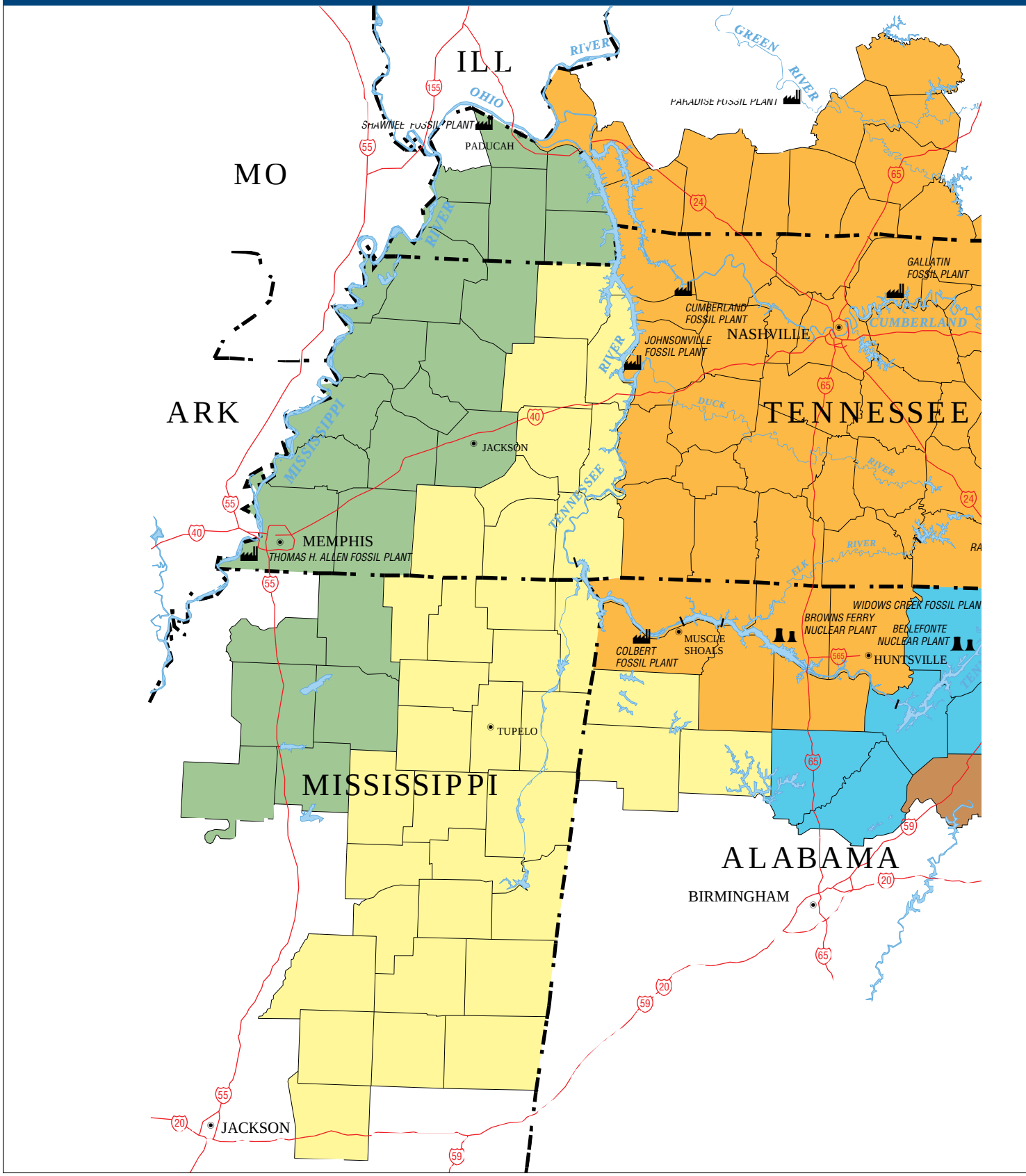
Power plant emissions are one of several stressors to forests in the Tennessee Valley. Power plant emissions and their potential effects have been discussed previously. Since the cumulative effects of various stressors can negatively affect forests, all key stressors are discussed in this section.

The forests of the Tennessee Valley are in a constant state of change. Presence or repression of fire, environmental conditions, people, and introduced pests have helped shape the current landscape. Forest stressors include past land use practices that resulted in erosion and site degradation, extreme climatic conditions (freezing injury, ice damage, drought, flooding), air pollutants, and exotic as well as native forest insects and diseases.

Currently, several stressors raise concern for the health of forests in this region. Tropospheric ozone is produced by complex photochemical reactions involving sunlight and the emission of volatile organic compounds and nitrogen oxides from automobiles, power plants, factories, and other sources of high temperature combustion. Ozone in the troposphere, the portion of the atmosphere 7 to 10 miles from the earth's surface, can occur at levels that cause visible injury to numerous plants and have potentially deleterious interactions with other forces in forest settings (Johnson and Lindberg 1992). Acidic deposition is also considered to be a forest health stressor, especially to red spruce *(Picea rubens)*, the most sensitive regional tree species.

A number of diseases and pests introduced to the Tennessee Valley have recently or will soon impact the forest (Ferguson and Bowman 1994; Great Smoky Mountains National Park 1993; Langdon and Johnson 1992). The gypsy moth *(Lymantria dispar)*, is of major concern. It is projected to reach the northeast

FIGURE T1-77. **The Five Major Forest Regions of the Energy Vision 2020 Study Area**



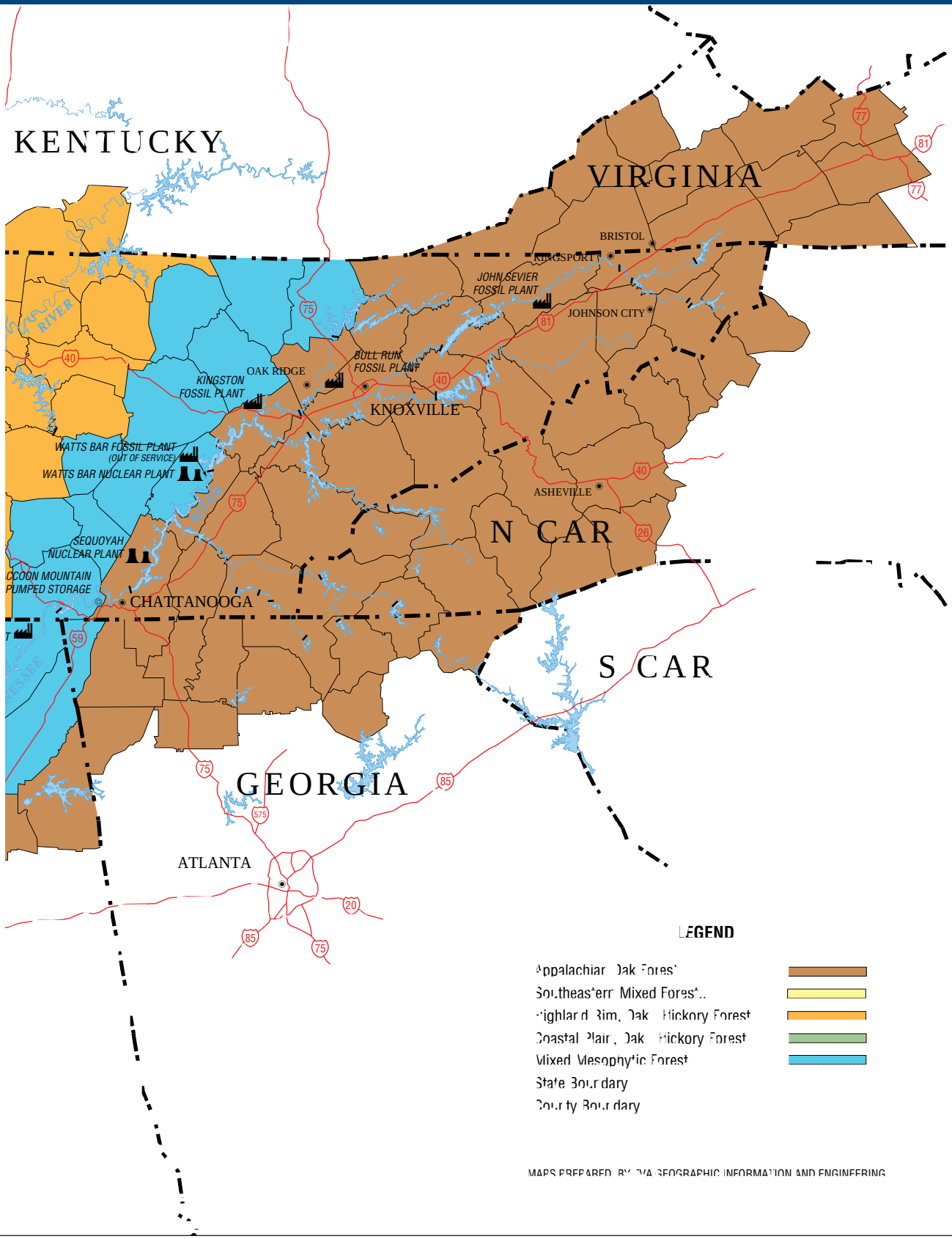

KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
BULL RUN FOSSIL PLANT
OAK RIDGE
KINGSTON FOSSIL PLANT
KNOXVILLE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
N CAR
SEQUOYAH NUCLEAR PLANT
CCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
S CAR
GEORGIA
ATLANTA
LEGEND
Appalachian Oak Forest
Southeastern Mixed Forest
Highland Rim, Oak Hickory Forest
Coastal Plain, Oak Hickory Forest
Mixed Mesophytic Forest
State Boundary
County Boundary
MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-78. Trees in the Major Forest Regions and Sections of the Tennessee Valley

The Mixed Mesophytic Forest Region—Cumberland Mountains Section

Tuliptree	*Liriodendron tulipifera*
Basswood	*Tilia heterophylla*
Sugar maple	*Acer saccharum*
Beech	*Fagus grandifolia*
Northern Red oak	*Quercus rubra*
Yellow buckeye	*Aesculus octandra*
White ash	*Fraxinus americana*
Cucumber magnolia	*Magnolia acuminata*
Red maple	*Acer rubrum*
Black gum	*Nyssa sylvatica*

Cumberland and Allegheny Plateaus Section

Beech	*Fagus grandifolia*
Tuliptree	*Liriodendron tulipifera*
Basswood	*Tilia heterophylla*
Sugar maple	*Acer saccharum*
Northern Red oak	*Quercus rubra*
White ash	*Fraxinus americana*
White oak	*Quercus alba*
Cucumber magnolia	*Magnolia acuminata*
Shagbark hickory	*Carya ovata*
Mockernut hickory	*Carya tomentosa*
Black gum	*Nyssa sylvatica*
Red maple	*Acer rubrum*

The Western Mesophytic Forest Region—Nashville Basin Section

Tuliptree	*Liriodendron tulipifera*
Sugar maple	*Acer saccharum*
White oak	*Quercus alba*
Northern Red oak	*Quercus rubra*
Hackberry	*Celtis laevigata*
American elm	*Ulmus americana*
Red cedar	*Juniperus virginana*
Winged elm	*Ulmus alata*
Shagbark hickory	*Carya ovata*
Black gum	*Nyssa sylvatica*
Chinkapin oak	*Quercus muehlenbergii*
Post oak	*Quercus stellata*
Redbud	*Cercis canadensis*
Beech	*Fagus grandifolia*
Wild cherry	*Prunus serotina*
White ash	*Fraxinus americana*
Bitternut hickory	*Carya cordiformis*
Fraser magnolia	*Magnolia fraseri*
Red maple	*Acer rubrum*
Chestnut oak	*Quercus prinus*
Black oak	*Quercus velutina*
Scarlet oak	*Quercus coccinea*

The Oak-Chestnut Forest Region—Southern Appalachians Section, Cove Hardwoods and Oak-Chestnut Communities

Basswood	*Tilia heterophylla*
Sugar maple	*Acer saccharum*
Northern red oak	*Quercus rubra*
Yellow buckeye	*Aesculus octandra*
Silverbell	*Halesia caroliniana*
Canadian hemlock	*Tsuga canadensis*
Yellow birch	*Betula lutea*
Sweet birch	*Betula lenta*

The Oak-Pine Forest Region—Gulf Slope Section

Chestnut oak	*Quercus prinus*
Pignut hickory	*Carya glabra*
Loblolly pine	*Pinus taeda*
Shortleaf pine	*Pinus echinata*
Southern red oak	*Quercus falcata*
Post oak	*Quercus stellata*
Black oak	*Quercus velutina*
Blackjack oak	*Quercus marilandica*
Mockernut hickory	*Carya tomentosa*

Southeastern Evergreen Forest Region—Mississippi Alluvial Plain Section

Silver maple	*Acer saccharinum*
American elm	*Ulmus americana*
Pin oak	*Quercus palustris*
Cottonwood	*Populus deltoides*
White oak	*Quercus alba*
Sweetgum	*Liquidambar styraciflua*
Cherrybark oak	*Quercus pagodaefolia*
Sycamore	*Platanus occidentalis*
Black oak	*Quercus velutina*
Red mulberry	*Morus rubra*
Sassafras	*Sassafras albidum*
Walnut	*Juglans nigra*
Honeylocust	*Gleditsia triacanthos*

corner of Tennessee in 15 to 20 years. Oak trees are the most susceptible. Stands with a higher component of oaks are also more susceptible to dieback and decline. Oak decline, a slow-acting disease complex, is caused by a combination of age, stress factors, and normally non-aggressive insects and fungi. A natural process, oak decline, is hastened and compounded by past land use, loss of species such as the American chestnut *(Castanea dentata*), replacement with species less adapted to the site, and other conditions.

Dogwood anthracnose is a disease caused by the fungus *Discula destructiva*. It was detected in the southern Appalachians in the late 1980s and has spread throughout much of the Valley. Flowering dogwood *(Cornus florida)* is the target species. At some sites all dogwood trees have been killed, while some trees at lower elevations on drier sites have sustained little damage. Other hardwood diseases include Dutch elm disease, caused by the *Ceratocytis ulmi* fungus, which attacks American *(Ulmus americana)*, slippery *(U. rubra)*, and winged elms *(U. alata)*. High levels of mortality among elm trees follow disease outbreaks. Butternut canker, caused by the fungus *Seriococcus clavigineti-juglandacearum* has a lethal effect on butternut *(Juglans cinerea)*. This fungus went unnoticed in the southeastern United States until less than a decade ago. Butternut populations are plummeting, and in 1990 butternut was added to the federal list of candidates for protection by the Endangered Species Act. Beech bark disease was detected in the Great Smoky Mountains several years ago. The disease is caused by a combination of the beech bark scale insect *(Cryptococcus fagisuga)* and the *Nectria* fungus. High levels of American beech mortality are expected if the disease spreads.

Three insects are serious pests to Valley coniferous forests (Ferguson and Bowman 1994). The balsam woolly adelgid *(Adelges piceae)* was detected in the southern Appalachians in the late 1950s. It is a non-native mortal pest of mature Fraser fir *(Abies fraseri)* native to the southern mountains. Virtually all natural stands of fir have been infested, and few mature firs remain. The hemlock woolly adelgid *(Adelges tsugae)*, accidentally imported from Asia, has already infested many Eastern hemlocks in Virginia. Widespread mortality is expected. This adelgid is expected to move throughout the Appalachians and may eliminate most of the hemlock, both the Eastern type and the native Carolina hemlock *(T. caroliniana)*. Most species of conifers are susceptible to attack during intense outbreaks by the native southern pine beetle *(Dendroctonus frontalis)*. In the Tennessee Valley all shortleaf, loblolly, and Virginia, Table-Mountain pines *(P. pungens*) pitch pines *(P. rigida)*, and eastern white pines *(P. strobus)* are attacked. Overstocked or homogeneous stands are the most susceptible to high mortality during periodic beetle outbreaks.

Harmful non-indigenous invasive plant species also pose a threat. Both privet *(Ligustrum*.spp.*)* and Japanese honeysuckle *(Lonicera japonica)* are shade-tolerant and form a dense layer of low vegetation, altering forest regeneration patterns. Another pervasive shade-tolerant plant is bittersweet *(Celastrus scandens)*, but it is not yet known to hamper stand regeneration. The grass microstegium *(Microstegium vimineum)* carpets moist forest understories, changing the composition of the herbaceous layer. Some shade-intolerant species introduced, such as autumn olive *(Elaeagnus umbellata)*, multiflora rose, *(Rosa multiflora)*, and kudzu *(Pueraria lobata)* can cause local problems. A potential problem species that is spreading south is mile-a-minute weed *(Polygonum perfoliatum)*, an aggressive annual spread by animals that eat its fleshy fruits.

Usually these pests, pathogens, or agents of damage are viewed individually. However, they often work together and impact the forest through a multiple stressor system complex.

SENSITIVE OR THREATENED ECOSYSTEMS

The TVA region includes several terrestrial communities that are either restricted to the TVA region, are best represented here, or include a large proportion of their total area in the region. These include the Southern Appalachian spruce-fir, cedar glade, and limestone cave systems. Several endangered and native plant and/or animal species, as well as species not found outside the TVA region, occur in each of these communities. Therefore, knowledge of these threatened ecosystems is important for the future implementation of energy resources including the site-specific environmental reviews to be performed.

Southern Appalachian Spruce-Fir Forest

The Southern Appalachian spruce-fir forest is an ecosystem rich in animals and native and rare plants. However, these forests have experienced serious disturbances in the last century. Commercial logging and associated fires of the early 1900s reduced the forests to a fraction of their former expanse (Korstian 1937). Currently these forests are being severely impacted by the balsam woolly adelgid, an imported insect first detected in the southern Appalachians in the late 1950s (Spears 1958). Mature Fraser fir, a southern mountain endemic, is highly susceptible to the adelgid, with death occurring in two to seven years after infestation. Furthermore, some evidence suggests a red spruce growth decline in the past 20 years, as well as canopy crown deterioration since the mid-1980s (Peart et al. 1992; McLaughlin et al. 1987).

The red spruce-Fraser fir ecosystem occupies approximately 103 square miles in the southern Appalachian mountains of southwestern Virginia, eastern Tennessee, and western North Carolina and is generally confined to mountain peaks above 5,000-

foot elevation. The larger stands are shown in the map in *Figure T1-50*. Spruce-fir forests occur as a series of island-like stands at high elevation. The largest contiguous area of red spruce-Fraser fir forest (48,721 acres) is located in the Great Smoky Mountains National Park (Dull et al. 1988). The remaining 26 percent of the ecosystem is located in the Black Mountains (7,221 acres), Balsam Mountains (4,648 acres), Roan Mountain including Unaka Mountain (1,699 acres), Mt. Rogers Area including Whitetop Mountain (1,582 acres), Plott Balsams (952 acres), Grandfather Mountain (928 acres), and Long Hope Mountain (498 acres) (Dull et al. 1988; Groton 1985).

Cedar Glades

Cedar glades are areas of exposed limestone bedrock, gravel, and/or shallow soil over limestone bedrock, sparsely vegetated with low-growing herbaceous plants and red cedars (Quarterman 1989). Their greatest concentration occurs within the Interior Low Plateaus physiographic province in central Kentucky, central Tennessee, and northern Alabama. A few glades also occur within the Ridge and Valley province of Virginia, Tennessee, Georgia, and Alabama. Twenty-two species or subspecies of plants are only found on these southeastern glades. The total area of cedar glades, most of which are within the TVA region (Baskin and Baskin 1986), is only a few thousand acres. Many have been destroyed or heavily disturbed by urban and suburban development, highway construction, and reservoir impoundment.

Caves

Over 5,000 caves and related Karst features such as sinkholes have been identified in the TVA region (TVA undated). They are widespread in the eastern two-thirds of the region. Many species of invertebrates, as well as one fish, and one salamander, are restricted to caves in the TVA region. Several of these species occur in only one or two caves. Several of these species, as well as several bats inhabiting caves, are listed as endangered or under consideration for endangered listing. Important stresses to cave ecosystems include groundwater pollution, changes in cave climate and hydrology resulting from modifications to cave entrances, and disturbances to cave formations and fauna by human visitation.

THREATENED AND ENDANGERED SPECIES

Knowledge of threatened and endangered species in the TVA region is important for the future deployment of energy resources including the site-specific environmental reviews to be performed. Thirty-eight species of plants and 100 species of animals in the TVA region are either listed as endangered or threatened species or formally proposed for such listing by the U.S. Fish and Wildlife Service (USFWS). These species, their distribution by river basin, and their habitats are listed in the Threatened and Endangered Species Appendix. An additional 380 species in the TVA region have been identified by the U.S. Fish and Wildlife Service as candidates for listing (USFWS 1993, 1994a, 1994b). The distribution of many candidate species is poorly known and not included here.

The 83 aquatic animals are endangered by loss of habitat due to the building of reservoirs; alterations of flow, temperature, and water chemistry regimes in river stretches downstream of dams; stream channel modifications such as channeling; and habitat degradation from point and non-point pollution. Most plants and terrestrial animals are endangered by loss of habitat due to land use changes such as agricultural clearing, highway construction, and suburban development.

The 83 aquatic species presented in the Threatened and Endangered Species Appendix occur in 4 broad habitat types, 3 of which have been described in some detail in Section 3, Water Resources in this document (Volume 2, Technical Document 1, Comprehensive Affected Environment). Under-ground aquifer habitats, not mentioned in Water Resources, are inhabited by three listed species. Each of these species (Alabama cavefish, *Speoplatyrhinus poulsoni;* Alabama cave shrimp, *Pulaemonias alabamae;* and Kentucky cave shrimp, *Pulaemonias ganteri*) occurs in one or a few caves located in an extremely limited geographic area.

The vast majority of the listed aquatic species presented in the Threatened and Endangered Species Appendix (65 of the 80 remaining species) typically occur in smaller rivers and creeks that have not been substantially affected by impoundment or other large-scale modifications. Twenty-five of these species occur in various Gulf drainages, while the remaining 40 species occur in interior basin streams, primarily the Tennessee and Cumberland river systems. Most of these small-stream listed species survive where habitat conditions and aquatic communities retain much of their original characteristics. Several of these species occur together as members of diverse communities in important and often protected stream reaches such as the upper Clinch, Powell, and Duck rivers in the Tennessee system; the middle portion of the Green River; and the Cahaba River, Mobile system.

Tributary reservoirs and their tailwaters make up the second aquatic habitat discussed in Water Resources, but they contain no listed species. Since these habitats are substantially different from the original character of the streams they do not meet the needs of listed species.

Large river habitats, even though substantially affected by dams, still support surviving populations of 15 listed species included in the Threatened and Endangered Species Appendix. Four of these species occur in the Mobile River system, while the other 11 exist in the mainstreams of the Tennessee,

Cumberland, Ohio, Green, and/or the Mississippi rivers. Most of these species survive in sections of large rivers where important original habitat conditions persist. Often these sections occur just downstream from the dams. Several of these species typically occur together as parts of diverse communities in locations such as the Tennessee River downstream from Pickwick Landing Dam and the Cumberland River downstream from Cordell Hull Dam.

UNIQUE AND SIGNIFICANT NATURAL AREAS

Siting of power plants and emissions for pollutants from power plants can potentially affect unique and significant natural areas. Site-specific environmental reviews would address any impacts to these areas as future resources are implemented. Natural areas in the TVA region include national, state, and privately owned lands that are managed for significant ecological resources, including forest, wildlife, water, rare plants and animals, or research. Most areas are managed to maintain their wild character and scenic beauty, to serve as a vital habitat for migrating birds and large mammals or endangered species, to provide important outdoor recreation resources in natural landscapes, or to serve as a nature educational tool. Many areas are managed to allow natural processes to predominate.

Natural areas contain an array of significant natural resources, from large wilderness areas, national wildlife refuges, and national parks, to intensively managed forests and recreational parks. Aquatic natural areas include state and national scenic rivers, mussel sanctuaries, and critical habitats for rare fishes. Natural areas vary in size from a few acres to several thousand acres. Many cross state boundaries or are managed cooperatively by several agencies. Categories of natural areas can be found at the end of this document in the Seventeen Categories of Natural Areas Appendix.